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Research efforts in environmental psychology often involve complex environments requiring specifically designed experimental technology to permit both causal inference and reliability/validity of the obtained data. A number of research methods centering around simulation and gaming methodologies are examined for their applicability to problems in environmental psychology. Among others, a recently developed quasi-experimental simulation method is discussed.

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Simulation and Related Research Methods in Environmental Psychology*

Siegfried Streufert
College of Medicine, The Pennsylvania State University
Hershey, PA

and

Robert W. Swezey
Science Applications Inc., McLean, VA

While there are certain commonalities in the approach of the sciences in general to their respective subject matters, each discipline must adapt its methods to the specific phenomena under investigation. To a lesser, but nonetheless substantial degree, the same may be said for the diverse branches of individual sciences: it would be preposterous to suggest, for example, that environmental psychology should use exactly the same methods that we know from research in learning theory. Environmental psychology is different: in contrast to at least some of the other "psychologies," the field often deals with human behavior in response to or in interaction with quite <u>complex</u> stimulus settings. It is then hardly surprising that the observed human responses to multi-faceted environments tend to be

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multi-faceted and complicated as well. Environmental psychology must be able to capture the complexities of the environment as well as the complexities of the resultant human responses. In other words, to have wide predictive validity, at least some of the methods used in environmental psychology should bear considerable relationship to the complexity of the stimulus environment and to the complexity of the associated responses. At least these methods should not depart far enough from that complexity to destroy the potential of what might be termed a "meaningful level of analysis."

This chapter deals with research methods which attempt to reflect the complexity of the environmental variables to which people are typically exposed when they function in the "real world" surrounding them in many of their day-to-day activities. The methods under consideration represent an effort to obtain both external and internal validity without sacrificing more than minimal reliability and applicability of the obtained data. The focus will be on simulation and related research approaches such as computer modeling, role playing, and so forth. The advantages and disadvantages of these approaches to research in environmental psychology are considered. Some examples and suggestions of how these methods may be useful to environmental psychologists and related researchers are provided. While the methods considered in this chapter are certainly not the only research techniques which are important to this field, they are central to at least some of the questions that are a pivotal part of the field of environmental psychology.

The Function of Multiple Variables

The majority of human behavior occurs in complex environmental settings, i.e., people are typically exposed to a number of stimuli simultaneously. This typical complexity of real-world environments was for a time aversive to behavioral scientists: it was assumed that quality science would have to focus on single elemental stimuli and measure single, equally elemental, responses. External validity was sacrificed to obtain internal validity since it was assumed that only one kind of validity could be achieved (e.g, Aronson and Carlsmith, 1968). Objections to such arguments were soon to come. For example, Fromkin and Streufert (1976) suggested that phenomena could not be subjected to reductionism beyond a certain minimal level without loss of their essential characteristics, or, as Streufert and Streufert (1978) have stated, beyond their "minimum common denominator." Obviously, the level of this common denominator often rises with the number of variables under simultaneous consideration, and with the degree to which these variables represent quite disparate phenomena.

As suggested above, environmental psychology investigates behavior which often occurs in complex settings where people are simultaneously exposed to a number of stimuli. Considerable research has shown that such complex settings have effects above and beyond the kind brought about in simple settings that are more easily (and more typically) reproduced or created in the laboratory experiments common to a number of other areas of psychology. For example, findings from environmental stress research tend to show that any single stressor has quite limited effects on human responsing until that stressor reaches severe levels. Yet several stressors operating simultaneously, even at relatively mild levels, can combine to produce increased physiological arousal, dissatisfaction, and serious detriments in social and/or task performance. In other environmental settings, however, the results may be reversed: the simultaneous or subsequent occurrence of a number of stimuli may even have ameliorating effects. For example, would someone who is having a serious disagreement with the boss respond (socially or in terms of physiological arousal) as severely if he or she knows that there will be someone at home in another hour who will be comforting and understanding? Would that response be different if another argument is expected at home? At present, we are only beginning to understand the diverse responses to interactive stimuli and their cognitive representations. We must realize that we cannot avoid studying these interactive characteristics of environmental variables if we wish to accurately predict the effects of complex environments on complex human behaviors. Fortunately, we now have techniques which permit us to engage in such efforts. In some research efforts in environmental psychology, we may wish to measure the effects of several interacting variables across a number of levels; in other cases, we may wish to study some of them as boundary variables and others as independent or dependent variables (c.f. Fromkin and Streufert, 1976). In either case, we cannot ignore their individual or interactive contributions to human responding in complex environments. In the following section we shall take a closer look at some of the methods which were designed to help us study variables which are inherent in complex environments and their impact more effectively.

Simulations and Other Methods Which Apply to Complex Environments

Simulations were first developed in the physical and engineering sciences. Aircraft design engineers, for example, might place an operating model of a future airplane within a wind tunnel to determine the flight characteristics of that aircraft. Such a procedure would allow identification of potential problem areas and would lead to improvement of airframe design. The success of simulation procedures in engineering suggested adaptation of the technique to other fields as well. A number of years ago, Guetzkow and his associates discovered the value of simulation for behavioral, social, political and organizational sciences (e.g., Guetzkow, 1962). These researchers suggested than an operating model of a social organization should be built and tested in the same fashion in which aircraft engineers test the design of a fuselage or wing structure. With the advent of simulation techniques in the behavioral sciences, the ground was broken and several, more or less related methods were developed to measure the effects of relatively complex environmental, task and individual variables as they interact with each other.

Simulations and their relatives among research methods tend to place participants, either individually or in groups, into more or less realistic task environments. Typically, the task provided to simulation participants is identical to or only marginally abstracted from tasks which people perform in the real world. Participants (subjects) may act as themselves (i.e., they are given some task to complete). In some research, the participants may even be hired to do a job and have no idea that the "company" which hired them represents a research effort. In other cases, the participants may be assigned a task which they, themselves, normally would not experience, yet the task is often sufficiently interesting and involving so that the feeling of being in an experiment soon gives way to goal orientation and "normal" experience.

Simulations differ from other experimental methods, not only in the complexity of the work (and variable) environment, but also on the time dimension. Simulations have been defined as "construction and manipulation of an operating* model" (Dawson, 1962), as an "operating representation of central features of reality" (Guetzkow, 1963). They may potentially take several forms: they may look like games, they may be computerized, they may employ people and computers. In any case, they occupy both space and time (Inbar and Stoll, 1972). To summarize, simulations and related methods <u>operate</u> in complex environments <u>over time</u>. Participants are exposed, either through feedback from their own actions, through preprogrammed environmental

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*Obviously an "operating model" is not static: it must <u>continue</u> on the <u>time</u> dimension. How variables are treated over time is, as will be explained below, a major parting point for diverse kinds of simulation techniques.

events or some combination of these two to a continuously modifying environment (c.f., Streufert and Suedfeld, 1977). Within the limitations of their resources, the participants are able to perceive, to respond and to initiate actions. In some forms of simulated environments these perceptual and behavioral options are more restricted, in others, practically no restrictions exist at all (see below). In all of the simulation techniques and related research methods, however, the experimenter is able to observe human responding to complex stimuli of interest in a relatively realistic environmental setting. Moreover, these responses are observed as they develop and change over time.

Before proceeding with a description of the specific research methods represented by the simulation family, a word of caution is in order. Researchers in psychology, including environmental psychology, have recently misused the term "simulation" in a large number of publications. While definitions of concepts can change, a modification of the meaning of "simulation" is not advisable, since psychologists, in changing the meaning of the term, would sharply differ from the rest of the scientific community. As discussed below, simulation represents an <u>ongoing</u> process in which persons interact continually with an active complex environment. Responding to paper and pencil questions on how one would respond to some environmental change, how one would vote if selected for a jury and so forth <u>does</u> represent experimentation. It does <u>not</u>, however, represent simulation research. Several of the required components of the simulation method, in particular the ongoing interactive environment over time, are missing (c.f., Streufert and Suedfeld, 1977).

Free Simulations

Fromkin and Streufert (1976) have termed the simulation techniques developed by Guetzkow and associates (e.g., Guetzkow, 1959; Guetzkow, Alger, Brody, Noel and Snyder, 1963) "free" simulations. In free simulations, participants are free to choose their own courses of action (within the constraints of their resources and the limitations of given rules). More importantly, they also are free to modify the environment through their action over time. The result of such activity is a simulated system in which the individuals, groups, teams or organizations that operate as participants in the simulation produce changes in their environment over time. Obviously, their subsequent responses to those changed environments will differ from participant to participant since they must be based on the diverse stimulus configurations that have developed.

Free simulations have been used for a large number of purposes (c.f., Inbar and Stoll, 1972; Shubik, 1960). To Guetzkow and his associates and to many other researchers associated with this particular point of view, the free simulation represents a model or theory of some behavior under analysis (e.g, Guetzkow, Kotler and Schultz, 1972; Inbar and Stoll, 1972). The goal of a free simulation is most often the prediction of real world events that might defy understanding by the human mind because of their inheret complexity. For example, if some event is determined by an interaction of 50 or so variables, the human brain lacks the capacity to understand it. We cannot, for example, cognitively conceptualize fifty-way interactions. Nonetheless, the proponents of free simulations would argue that we might replicate such complex historical events and learn to anticipate future events if these events will naturally occur in a simulated setting that contains all essential variables. Because of its postulated capacity to predict future events, the free simulation (often computerized, i.e., players are replaced by parameters*) may be considered a theory.

As an attempt at successive approximations toward a better and better theory (with repeated improvements of parameters), the free simulation lacks the needed ingredients to be widely useful for experimental research on the relationship among specific variables. Since the participants in free simulations are able to modify their environments, groups of subjects in one simulation would produce and, consequently, experience quite divergent environmental stressors (after some time) than any other group placed into the same simulation. Experimental comparisons among groups of participants in free simulations is consequently limited to the interpretation of outcomes as a function of common (or planned diverse) starting points.

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*See the section on computer simulations, below.

Nonetheless, some researchers have utilized free simulation techniques for experimental purposes. One of the earliest efforts in this direction was reported by Driver (1962) who studied the behavior of simulated nations within Guetzkow's (1963) Internation Simulation (INS) system. An environment was devised within which two large powers with allies of various sizes interacted economically, politically and militarily. Because of the changes which different groups of subjects produced as they operated as national decision makers in the simulation, Driver was only able to study the effects of different initial conditions in the simulated environment. Nonetheless, he obtained quite interesting results. For example, his data point toward the possibility that a moderate size power with nuclear arms capacity in a political environment dominated by two large powers that are in political conflict might fire a nuclear rocket at the major powers, hoping that they will exhaust each other in a subsequent war, leaving the moderate size power to take control.

Experimental Simulations

To obtain experimental control over independent variables across time, Streufert, Clardy, Driver, Karlins, Schroder and Suedfeld (1965), and Drabeck and Haas (1967), in separate efforts, developed experimental simulation techniques.

Experimental simulations contain the same environmental complexity to which we have become accustomed from free simulation techniques. Participants in this form of simulation are led to believe that they are interacting with an ongoing environment, and that their actions, behaviors and decisions affect that environment in turn. Participants in experimental simulations believe that the outcomes to which they will be exposed in the future are in some part direct consequences of their own previous activities. In fact, however, experimental simulations utilize an environment which is controlled by the experimenter. The experimenter may select one or more independent variables and manipulate these variables over time according to the research design. Other variables are held constant or randomized. The events to which participants are exposed thus actually reflect the operations of independent variable manipulations, rather than the effects of previous participant behavior. In well designed experimental simulations, the participant does not realize that behavior is without direct effect on future outcomes.

Obviously, such a research technique has great advantages for experimenters who wish to measure effects of multiple controlled variables in complex, real-world environments. The technique has proven valuable in environmental and organizational experimentation within a variety of settings, and has produced useful data both for theoretical and for applied purposes. However, experimental simulations tend to be restricted to research efforts and theory testing. Because of experimenter control over potentially all environmental variables, the experimental simulation technique <u>per se</u> can generally not be considered to be a theory or a model.

Some examples of experimental simulation methodology may be useful. In one of the earlier efforts with this technique, Drabeck and Haas (1969) simulated the environment of a police dispatcher. By using police dispatchers operating as simulation participants at their usual work stations, these researchers obtained a high degree of external validity. To obtain performance measures under environmental (input overload) stress, Drabeck increased the load on the dispatcher by introducing specific numbers of calls to the dispatch operation in addition to the incoming "normal" calls. Similar methods were also used by Streufert and Schroder (1956) and Streufert and Driver (1965) in an earlier simulation of tactical decision making. In the latter case, all inputs to decision making teams were pre-programmed and precisely controlled in number (from two to forty per thirty-minute period) and in their degree of complexity (each input consisted of a simple subject-predicate-object statement from which only a single informative statement could be obtained). Research of this nature has been exceptionally productive since a number of different dependent variables (e.g., diverse measures of performance, perceptual characteristics, attitudes, satisfaction, group oriented behavior and many more) can be measured in response to the same carefully controlled, but complex environmental setting. Moreover, the effects of variable levels introduced sequentially over time can be obtained, increasing the wealth of data even more (see below for cautions on the interpretation on multiple data sets obtained from single sets of participant groups). Experimental simulation research has, for example, repeatedly demonstrated that complex strategic behavior occurs at its highest levels during intermediate load conditions (i.e., when an item of information is presented approximately once every three minutes) while simple responsive behavior rises with increasing environmental stimulation until the maximum response capacity of the human responder (or group) is reached.

Quasi-Experimental Simulation Procedures

Streufert and Swezey (1980) have suggested that it is possible to design a quasi-experimental simulation which combines the desirable effects of free simulations with those of experimental simulation techniques. Basically, such a method could provide participants with direct feedback based upon previous actions. At the same time, it could also allow retention of experimenter control over relevant experimental variables. Such a technique borrows control of independent variable manipulation over time from experimental simulation methodology, but applies that control only to variables that are of specific interest to an experimenter. Other variables which may be held constant or randomized in an experimental simulation can be freed to vary "realistically" as a function of the actions of participants and potentially of established parameters.

The conceptualizations upon which quasi-experimental simulation technology is based are quite similar to the thoughts on which Campbell and Stanley (1963) based their quasi-experimental research design paradigms. If an environment of interest to the researcher is too complex to fit within the rather rigid and restrictive requirements of standard experimental technology, quasi-experimental methods may be used to allow the setting to remain "natural" yet to gain the necessary control over important components of that environment and thus to allow inference of causality in predicting dependent variable data from independent variable events or manipulations. Quasi-experimentation is a necessary compromise between the limitations imposed by working with real-world phenomena and the desire to obtain meaningful and reliable data.

The experimenter using quasi-experimental simulation technology can, of course, select those variables to be manipulated, as well as those that are left to vary freely with the actions of participant subjects. Obviously, independent variable(s) of interest to the research must remain under experimenter control. Variables that are likely to interact with the independent variable(s) should also be controlled. To the degree to which control can be extended further to cover other environmental and event characteristics in the simulation, the advantages of experimental simulation methodology are approached and the problems associated with free simulations are reduced. To the degree to which control is relaxed, realism may be increased further, but the potential confounding problems found in free simulation technology may emerge. To make best possible use of the quasi-experimental "compromise," the research design that most closely approximates the experimental simulation paradigm within the given circumstances should be selected.

An example of a specific quasi-experimental simulation might be useful here. Among other simulated environments, Streufert and associates developed the Tactical and Negotiations Game (Streufert, Kliger, Castore and Driver, 1967), where participant subjects make decisions about the economic, military, intelligence and negotiation components of a small internation conflict. The participants arrive at the lab and are presented with a manual which informs them in detail about history, current conditions and their task in a country called "Shamba." They are to resolve the Shamba conflict, a limited international conflict situation with some similarity to several real-world problems in recent history. Via the manual and some video presentations, the participants spend about three hours in which they receive the necessary pre-training and the persuasive communications that reliably lead them to "believe in" the cause they are representing.

As the simulation begins, they believe that they are faced by an opposing decision making group that represents the other side. They may interact with that other group in written form (i.e., at a distance) as long as they do so within the resources they have according to the manual. It appears to them that the events which occur with time are the direct effects of their own decisions as they interact with the decisions of their opponents. In other words, they learn to believe that they can and do have a direct effect on their own future. That effect, however, is only partial. The supposed opposing group's actions (if any other group is present at all) have no effect at all on the outcomes of the participant's decisions. Some outcomes of participants' actions are determined via predetermined parameters (relationships among variables). For example, a greater investment of money into an environmental clean-up fund may actually produce a cleaner environment as long as that outcome does not interfere with variables of interest to the experimenters. If, for example, success levels of information received were of interest (or might confound some other important variable) or if the experimenters wanted to investigate the effects of environmental pollution on the actions of their decision makers, then the parameter relationship would be replaced with a preprogrammed fixed outcome.

While the experimenters may allow some variables (that are not of experimental interest and are not likely to confound) to vary with the actions of the participants in the quasi-experimental simulation, they would maintain strict outcome control over those independent variables that are of interest in the research design. If, for example, the interest would be in information load (amount of information coming from the environment per unit time), then only a limited number of information statements from the environment would be permitted (spaced as appropriate for the research design). Further, since we know that failure information tends to increase effective load levels, participants in a research design measuring the effects of environmental load would have to be exposed to failure levels held constant at a zero or some other interesting level to eliminate potential confounds.* Other characteristics of the information to be

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*See below for problems generated by unknown confounding variables.

received by the participants could, however, be responsive to the previous actions of the participants. For example, in a research effort studying the effects of environmental load, the content of the information messages would be of lesser importance and could well vary with previous decisions made by participants. If the decision had been made to invest funds in the construction of a refinery, an informative statement that the requested amount had been deposited in the appropriate account would be reasonable. It would be equally reasonable for the participants to receive a message stating that the construction of the plan had been started as long as the message would not increase the load level beyond that planned for the manipulation.

Games

Games are research techniques where rules are provided and players usually have few alternatives in responding to the moves (actions) of opposing players. More likely than not, games are of zero-sum nature, i.e., a win for one player represents a loss for the opponent. Games (parallel to simulations) may be either "free," "experimental," or "quasi-experimental" in nature. Thus, the players may operate either against a fixed predetermined program or may play against a partially or fully responsive program/opponent. While playing an experimental game could certainly be surrounded with extensive information about underlying environmental conditions, about preceding events and so forth, such complexity has typically been avoided by the researchers employing this medium of data collection.

Using games for measuring human responding to environmental stimuli reflects the underlying assumption that a simplification of environmental conditions and environmental stimuli (by reduction in number or in levels of occurrence and levels of potential responsivity) does not violate relationships between the independent and dependent variables of interest. Considerable gaming research, based on the well known prisoner's dilemma and related paradigms (c.f., Deutsch, 1958; Deutsch and Krauss, 1960, 1962) and later developed toward considerable levels of sophistication (e.g., Rapoport, 1963, 1966, 1968, 1969, 1970, 1974b) has been claimed (at times by authors, at times by reviewers) to have wide-ranging implications for environments as complex as the internation system of politics (c.f., Rapoport, 1974a). Certainly, such assumptions can be met with considerable doubt. Nonetheless, games may be useful if we know with some certainty that variable relationships of interest are indeed likely to be simple and unaffected by extraneous variables that cannot be included in simple game settings.

Role Playing

In the typical role playing task, a person or group of persons imagine themselves in the role of another (or in some cases in a future situation they, themselves, could experience). They try to report how they would behave in the imaginary environment, or report (or act out) how they believe another person would behave.

Some writers have suggested role playing as an alternative to simulation and/or laboratory experimentation, or have not clearly distinguished between role playing and simulations (or games) as a basis for research design (e.g., Crano and Brewer, 1972). Certainly role playing has seductive qualities. As a technique, it requires little preparation and effort, no props and usually little or no equipment. More importantly, there is absolutely no deception of subjects involved (c.f., Kelman, 1967). In other words, for those who would trust that people's role playing responses would be identical or similar to their responses to a "real" environment, this research method has many advantages.

Can one trust the accuracy of these predictions? Early investigations of role playing (comparison between role playing and other research techniques and a few comparisons between role playing and real world events) have shown that role playing <u>can</u> reproduce main effects that are observed both in experimental simulations and in post hoc analysis of real world events (e.g., Freedman, 1969). However, role playing techniques can rarely, if ever, demonstrate the complex interactive effects that other research techniques or real-world-based observations can produce (e.g., Freedman, 1969; Fromkin and Streufert, 1976; Willis and Willis, 1970). Meaningful role playing analysis must consequently be limited to the kind of simple settings that occur more rarely in the field of environmental psychology.

Role playing has (probably for good reason) not been a method of choice in environmental psychology. Nonetheless, it could have been employed albeit with limited success. Let us take, for example, the work of Nogami (1976) who varied both space available and number of persons present to measure the effects of density on various dependent variables. Certainly, this researcher could have asked subjects whether they _would_ feel crowded in specified (e.g., photographically presented) smaller and larger spaces. Possibly the subjects might have been able to report with some accuracy what size space might have begun to be perceived as uncomfortably crowded. Similarly, pictures of the number of persons present in a specified size space could have been shown to the subjects. Again, some accuracy of prediction might have been obtained. However, most likely the role playing subject would have been hopelessly lost in predicting the joint and interactive effects of number of persons and size of space on his or her perceptions and behavior in an actual crowded setting.

Computer Simulation (Computer Modeling)

Psychologists of various theoretical and content orientation (e.g., Abelson, 1968, Guetzkow, _et al_., 1972) have embraced computer simulations as their method of choice. Early computer simulations developed from free simulation methodology. As the typical behavior of persons, groups or other acting systems introduced into the simulation could be identified and mathematically specified, the human acting system became potentially unnecessary and could be replaced by a parameter statement, i.e., a precise statement of the relationship and/or interaction among the relevant variables of interest. As knowledge increased (or was thought to increase), more and more of these variable relationships could be mathematically described, more and more eliminating the need for persons as part of the simulation system. Naturally, as soon as all relationships among all variables that are part of a system of interest can be precisely and reliably specified, the entire system can be mathematically summarized in terms of parameter relationships.

Even before we know all relationships, we can make assumptions about those relationships that we do not yet know or understand. In the latter case, the mathematically described system could no longer be an accurate representation of reality, but rather a "theory" of reality. This "theory" can then be tested against real world events: With the introduction of some specified level of environmental variation in the real world <u>and</u> in the computer simulation, will the same outcomes occur? If not, then either some parameter statement needs to be corrected or not all of the complexities of the real world (variables and variable interaction parameters) are as yet represented in the computer simulation system. To state the characteristics of computer simulations somewhat differently: Such models are attempts at mathematical successive approximations of reality. Obviously, the approximation (the implied theory of reality) is limited by the degree of accuracy of the stated parameters. The accuracy of the parameters in turn is at least in part a reflection of our degree of reliable knowledge of variable effects and variable interactions in a relevant field of study. Environmental psychology as a relatively new field has so far obtained only limited knowledge of variables, their effects and interactions. As a consequence, the use of computer simulations in this field is likely premature.

A second use of computers is as a part of an overall man-machine system simulation. Here the computer merely fulfills a part of the systemic requirements; for example, it may operate as a source of input to simulation participants. While some parameter assumptions or environmental input specifications are typically involved in determining computer responses, the computer's role is basically an auxiliary one. In this form, computer assistance may in fact be desirable for research designs in environmental psychology. The use of computers in such situations, however, does not introduce any major changes into the basic research design characteristics. For example, the feedback to participants in experimental and/or quasi-experimental simulations can be handled with computer assistance.

Evaluation of the Available Research Methods for Complex Research in Environmental Psychology

From the above discussion, it is evident that methods such as role playing and gaming represent environments which are probably too simple to be relevant to many of the research concerns of environmental psychologists. It is probably equally evident that the time for computer simulations has not yet arrived. Much too much has yet to be learned about variables and their complex interactions to establish meaningful relationships among environmental variables in extensive parameter form. (This is not to argue that those who wish to approach environmental psychology from a purely mathematical modeling point of view should not be encouraged.)

What remains then, aside from approaches discussed in other chapters of this volume, are the various forms of simulation. Let us assume that we wish to test theory in environmental psychology. Or, let us assume that we merely want to operate on the principal of "I wonder what would happen if. . . .," based on an apparently reasonable hunch. What would be the advantages and the disadvantages of employing simulation in general and the different forms of simulation in particular?

Advantages and Problems of Simulation Designs

Simulations are compromises and, as such, display both the advantages and disadvantages that compromises tend to have. As scientists, we wish to obtain data with considerable precision. As human beings with an interest in the world in which we live, we want to obtain data and develop theory that is directly applicable to that "real world." Years ago, many of us argued for precise laboratory manipulations of smaller and smaller segments of variables, reducing events to minimum observable phenomena. We did obtain reliable data by this method, and we were able to increase the experimental validity of our efforts (e.g., the discussions of Aronson and Carlsmith, 1968). Others among us sat in "armchairs" and philosophized about the state of our environment. Some misguided environmental "philosophers" even provided grounds for some societies' arguments that war was the justified means to gain needed living space. Obviously, neither of these approaches can provide solutions that are defensible to those of us who wish to build a bridge from the experimental to the applied, i.e., those of us who want to make use of externally valid scientific information to understand and improve the environment in which we must survive.

Simulation techniques can provide us with some assistance toward this goal. They contain the internal validity sought after by those who were once so enamored with infinite regress. They also contain external validity favored by those who are looking for an applied science of environmental psychology. Yet, as stated above, simulations are compromises losing some degree of both external and of internal validity in the attempt to obtain both. Some "experimental validity" is lost because of the introduction of the larger number of variables which are simultaneously operative. On the other side, some of the "external validity" is lost since the researcher is not likely to recognize and, consequently, may not introduce all of the variables that are important to some "real world" environment. Moreover, the researcher may well be forced to consider some variables he or she recognizes as important to be boundary variables; for example, the researcher may find it necessary to treat some variables as constant at one level or to vary them at only a few levels or over a rather restricted range. As a result, some external and some internal validity may be lost.

Nonetheless, simulations have considerable advantages over other research methods when we are interested in predicting human behavior in complex environments. While there are some restrictions on internal validity and external validity, simulations are probably the most effective method to produce maximal amounts of both kinds of validity simultaneously within the same research design. Obviously, the selection of a particular simulation type will increase either one or the other of the validity levels and the choice should be based on the intents of the researcher.

Another primary advantage of simulation techniques is the high level of involvement which these methodologies can produce if they are well designed. If a simulation is interesting and appears realistic to the participants, it tends to produce the same level of involvement (and consequently equivalent resultant behavior) as is produced by the task and environment which the simulation represents. Because of this high level of involvement and because of the ability to manipulate variables "realistically," the experimenters can often select variables that could not be manipulated or even measured in the "real world" due to technical or ethical considerations.

Advantages and Problems of Free Simulations

Since free simulations do not permit an experimenter to control events over time, the experimenter is limited to introduction of the independent variable(s) at the time the simulation activities are initiated. Divergent environment starting points, various instructions, different resources, etc. are means for making (between group) comparisons of resultant behaviors in different groups of participant subjects. Such comparisons must be evaluated in terms of simulation outcomes. Either a cut-off point in time may be selected to compare the effects of different starting points on different sets of groups, or the experimenter may wait until an end product has been achieved. He or she may then measure the time it took to complete the task, the quality of task performance, the number of errors committed during the process of task completion, etc. Assuming all relevant environmental and task variables have been introduced into the simulation at appropriate levels, the observed and measured outcome is likely to be based on a natural and consequently realistic process, yielding considerable external validity, at least for the prediction of how any one group of participants could behave in a number of parallel situations. Unfortunately that external validity does not necessarily extend from one group of participants to the next.

Since different groups of participants behave differently, they are subsequently exposed to diverse environmental elements over time.* These diverse environmental characteristics may have unique effects which may alter, modify or even completely change subsequent participant behaviors. (Of course, it is possible to argue that such aspects of free simulations are in fact advantageous, since results which are repeatedly obtained from free simulation techniques are probably quite robust, having survived the interference of numerous confounding influences.) In other words, free simulations may well have applied value, but they tend to be too insensitive for purposes of general controlled experimentation or theory testing.

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*This problem may be less severe when the independent variables cannot be influenced by the behavior of the participants; for example, when such environmental conditions as temperature, uncontrollable noise, etc. are externally induced. Nonetheless, some effect of participant's actions might even exist here if the perception of or response to uncontrollable externally induced events is modified by events or situations that are the outcome of previous participant behaviors.

The major shortcomings of free simulation are the inability to: (1) measure planned effects of independent variables over time, and (2) introduce independent variable levels sequentially. For example, if we wished to investigate the effects of sudden bursts of environmental information or of required activities after a previous lull in information or activity, we could not obtain such data from a free simulation paradigm. In free simulation, no control exists over independent variable manipulations across time.

These shortcomings, at least from the standpoint of experimentation, seem to suggest that some form of a more experimental simulation paradigm is often preferable for purposes involving many complex environmental research designs.

Advantages and Problems of Experimental Simulations

Organizational psychologists have been concerned with simulation methods for some time. Such early writers on methodology in organizational psychology as Kennedy (1962) and Weick (1965), have pointed out that simulations can become quite unrealistic, if not well designed, thereby destroying desired effects upon participants. Weick (1965) was criticizing free simulations, since experimental simulation methods had not yet been extensively developed. However, the cited problem could be even worse for experimental simulation techniques, since the programming of information which reaches experimental simulation participants makes it even more of a challenge to maintain credibility. Subsequent work, however, (c.f., Fromkin and Streufert, 1976) has shown that it is possible (with some effort and considerable pretesting) to design experimental simulations that do not suffer from these defects. Simulations in environmental psychology are no exception to this rule.

A second potential problem for experimental simulations is their necessarily restricted nature. Due to the manipulation of controlled independent variables, experimental simulations are not typically as large as free simulations (i.e., uncontrolled fluctuations of events that may arise from the potential richness of many free simulation environments must be restricted in experimental techniques to enable realistic and complete control of experimental variables). This presents no major problem when a system of naturally limited size is being simulated; however, it may become an issue when the intent is to simulate a very large system with many interactive components.

Third, experimental simulations do not serve as well for early "I wonder what would happen if. . ." aspects of theory development. The spontaneous emergence of relationships among events (which an experimenter may not expect) are much less likely to occur in experimental than in free simulations, since the feedback loop from participant action-to environment reaction-to participant action is eliminated.

Despite those limitations, experimental simulations can be of great value when a realistic scenario and a realistic environmental input sequence can be designed <u>and</u> when the responses of individuals, groups, or organizations to specific environmental systems or to changes in environmental conditions over time are of value. Obviously, more effort has to go into creating a realistic experimental simulation than any other form of simulation. On the other hand, the data obtained are likely to produce even greater experimental validity than data gathered in other simulation methodologies.

Advantages and Problems of Quasi-Experimental Simulations

So far we have been concerned with the advantages and the problems a researcher in environmental psychology is likely to encounter in the use of free and experimental simulation methodologies. Since quasi-experimental simulation methods occupy a mid-point between the latter two techniques, one may reasonably ask the question about the extent to which such problems "survive" in a quasi-experimental simulation environment. One basic problem of free simulations, that of time effect discrepancies among participant groups, is reduced in the quasi-experimental paradigm, since those variables that are of interest to the experimenter are maintained under experimenter control across time. Nevertheless, other problems may remain. Since an effect involving participant actions on events outside of the manipulated independent variable(s) remains, discrepancies between outcomes one group of participants might experience in comparison to another group might also continue to exist. While such discrepancies will probably not have a major effect on the relationship between pre-selected independent and dependent variables, they could exert variable effects across participant groups on the dependent measures obtained. As a consequence, otherwise significant relationships between independent and dependent variables might be diminished. Similarly, marginal relationships between independent and dependent variables which might have been uncovered using pure experimental simulations may not reach required significance levels in a quasi-experimental situation. Thus, research which utilizes a quasi-experimental simulation for theory testing purposes may permit causal inference, but may nevertheless be limited in its ability to discover more marginal relationships among variables. The degree to which such problems might occur would, of course, depend upon the number of variables of interest that are maintained under experimental control (i.e., the degree to which such a simulation approaches either free or experimental simulation methodology).

Selecting a Research Method for a Research Effort in Environmental Psychology

It should be stated again that this chapter is concerned with research methods that are applicable to complex problems, i.e., research questions where a multifaceted environment is likely to produce a multi-faceted response in an exposed person, group or organization. This chapter is not an argument against experimentation in the laboratory where all but one variable are held constant: the knowledge obtained in that kind of research can certainly provide us with useful questions for investigations in more complex settings. This chapter is also not an argument against the brainstorming that occurs in the armchairs of more or less wise men. Again, their conclusions can provide the basis for conceptualizations or hypotheses which the applied researcher might utilize to design relevant experiments.

This chapter has argued that we do have some methods which provide us with reasonably good data when we wish to study the effects of complex environments on human behavior. The chapter has attempted to point out the shortcomings and the advantages of these methods. It is hoped that research will be carried out at a number of different levels: in the restricted lab, in the simulation environment and by observation in the real world whenever that is possible. To the degree to which the data obtained in these quite different settings do overlap or show degrees of identity, we can be more sure that we understand and know how to predict the phenomena in which we are interested.

Selecting an appropriate research method from those available must, of course, depend on the research question, on the variables of interest, on the ability to control and manipulate variables, and on the conditions under which observations are to be obtained. If the researcher wishes to utilize simulations or related methods, he or she may well start with a free simulation technique unless considerable data for at least some of the variables of interest have been collected previously. If conclusions are to be drawn from observed events and if relationships that are potentially important are, at present, purely hypothetical, then the researcher may learn much more by watching uncontrolled processes and interactions between environmental variables and the participating human beings. Once variables can be clearly defined, once predictions, or at least guesses, about relationships among variables can be stated, then quasi-experimental simulation designs or, if possible, experimental simulation designs tend to have greater advantages: more precision, more variable control, greater certainty about causal relationships, and finally more information about event sequences. However, the researcher must be aware that simulations become more difficult to design and that it is more difficult to achieve realism as we move from the more free to the more experimental methodologies.

One final note may be required. As Fromkin and Streufert (1976) have pointed out, simulations are very expensive to design and operate. Part of the high initial costs are due to the expense of "realism," others are due to the time requirements: Participants must be paid for several hours of participation in the simulation environment. On the other hand, the amount of data that can be collected in simulation runs is very large* and can cross modalities (e.g., data may in part be based on behavioral activity, in part on scale responses, in part on observer ratings, and so forth). As a result, while the cost of the simulation as a whole may be relatively high, unit data obtained from simulation methodologies tend to be inexpensive.

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*The collection of multiple data from a limited number of groups in specific experimental conditions can be criticized because constant errors due to non-random selection (error) might be evident in all sets of (within) data, producing potentially misleading results. As Fromkin and Streufert (1976) have pointed out, this problem can be diminished by partial replication (overlapping designs) of variable relationships (for more information, see Fromkin and Streufert).

Abelson, R. P. Simulation of social behavior. In G. Lindzey and E. Aronson (Eds.), Handbook of Social Psychology, 2nd Edition, Vol. 2, pp. 274-356. Reading, Massachusetts: Addison-Wesley, 1968.

Aronson, E. and Carlsmith, J. M. Experimentation in social psychology. In G. Lindzey and E. Aronson (Eds.), The Handbook of Social Psychology. Reading, Massachusetts: Addison-Wesley, 1968.

Campbell, D. T. and Stanley, J. Experimental and quasi-experimental designs in research. Chicago: Rand McNally, 1963.

Crano, W. D. and Brewer, M. P. Principles of research in social psychology. New York: McGraw Hill, 1972.

Dawson, R. E. Simulation in the social sciences. In H. Guetzkow (Eds.), Simulation in social science: Readings. Englewood Cliffs, New Jersey: Prentice Hall, 1962.

Deutsch, M. Trust and suspicion. Journal of Conflict Resolution, 1958 2, 265-279.

Deutsch, M. and Krauss, R. M. The effect of threat on interpersonal bargaining. Journal of Abnormal and Social Psychology, 1960, 61, 181-189.

Deutsch, M. and Krauss, R. M. Studies of interpersonal bargaining. Journal of Conflict Resoultion, 1962, 6, 52-76.

Drabeck, T. E. and Haas, J. E. Laboratory simulation of organizational stress. American Sociological Review, 1969, 34, 224-238.

Driver, M. J. Conceptual structure and group processes in an internation simulation. Part one: The perception of simulated nations. Princeton University and Educational Testing Service, ONR Technical Report #9, NR 171-055 and AF Technical Report AF 49(638)-742, and Research Report NIMH Grant M 4186, Princeton, New Jersey, 1962.

Freedman, J. L. Role playing: Psychology by consensus. Journal of Personality and Social Psychology, 1969, 13, 107-114.

Fromkin, H. L. and Streufert, S. Laboratory experimentation. In M. Dunnette (Ed.), Handbook of Organizational and Industrial Psychology. Chicago: Rand McNally, 1976.

Guetzkow, H. A use of simulation in the study of international relations. Behavioral Science, 1959, 4, 183-191.

Guetzkow, H. (Ed.), Simulation in social science: Readings. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.

Guetzkow, H. A use of simulation in the study of inter-nation-relations. In H. Guetzkow, C. F. Alger, R. A. Brody, R. C. Noel and R. C. Snyder (Eds.), Simulation in international relations. Englewood Cliffs, New Jersey: Prentice Hall, 1963.

Guetzkow, H., Alger, C. F., Brody, R. A. Noel, R. C. and Snyder, R. C. Simulation in international relations: Developments for research and teaching. Englewood Cliffs, New Jersey: Prentice Hall, 1963.

Guetzkow, H., Kotler, P. and Schultz, R. L. Simulation in social and administrative science. Englewood Cliffs, New Jersey: Prentice Hall, 1972.

Inbar, M. and Stoll, C. S. Simulation and gaming in social science. New York: Free Press, 1972.

Kelman, H. C. Human use of human subjects: The problem of deception in social psychological experiments. Psychological Bulletin, 1967, 67, 1-11.

Kennedy, J. L. The system approach: Organizational development. Human Factors, February, 1962, 25-52.

Nogami, G. Y. Crowding: Effects of group size, room size or density? Journal of Applied Social Psychology, 1976, 6, 105-125.

Rapoport, A. Formal games as probing tools for investigating behavior motivated by trust and suspicion. Journal of Conflict Resolution, 1963, 7, 520-579.

Rapoport, A. Two-Person Game Theory. Ann Arbor, Michigan: The University of Michigan Press, 1966.

Rapoport, A. Prospects for experimental games. Journal of Conflict Resolution, 1968, 12, 461-470.

Rapoport, A. Games as tools of psychological research. In I. R. Buchler and H. G. Nutini (Eds.), Game Theory in the Behavioral Sciences. Pittsburgh: University of Pittsburgh Press, 1969.

Rapoport, A. N-Person Game Theory. Ann Arbor, Michigan: The University of Michigan Press, 1970.

Rapoport, A. (Ed.), Game theory as a theory of conflict resolution. Dordrecht, Holland and Boston , Massachusetts: D. Reidel Publishing Company, 1974.

Rapoport, A. Prisoner's dilemma - recollections and observations. In A. Rapoport (Ed.), Game theory as a theory of conflict Resolution. Dordrecht, Holland: D. Reidel Publishing Company, 1974.

Shubik, M. Bibliography on simulation, gaming, artificial intelligence and allied topics. Journal of the American Statistical Association, December, 1960, 736-751.

Streufert, S., Clardy, M. A., Driver, M. J., Karlins, M., Schroder, H. M. and Suedfeld, P. A tactical game for the analysis of complex decision making in individuals and groups. Psychological Reports, 1965, 17, 723-729.

Streufert, S. and Driver, M. J. Conceptual structure, information load and perceptual complexity. Psychonomic Science, 1965, 3, 249-250.

Streufert, S., Kliger, S. C., Castore, C. H. and Driver, M. J. A tactical and negotiations game for analysis of decision integration across decision areas. Psychological Reports, 1967, 20, 155-157.

Streufert, S. and Schroder, H. M. Conceptual structure, environmental complexity and task performance. Journal of Experimental Research in Personality, 1965, 1, 132-137.

Streufert, S. and Streufert, S. C. Behavior in the complex environment. Washington, D. C.: V. H. Winston and John Wiley, 1978.

Streufert, S. and Suedfeld, P. Simulation as a research method: A problem in communication. Journal of Applied Social Psychology, 1977, 7, 281-285.

Streufert, S. and Swezey, R. W. Organizational simulation: Theoretical aspects of test bed design. McLean, Virginia: SAI Report No. SAI 80-101-178, 1980.

Weick, K. Laboratory experimentation with organizations. In J. G. March (Ed.), Handbook of Organizations. Chicago: Rand McNally, 1965.

Willis, R. H. and Willis, Y. A. Role playing vs. deception: An experimental comparison. Journal of Personality and Social Psychology, 1970, 16, 472-477.